PATENT SPECIFICATION

DRAWINGS ATTACHED

935,103

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International Classification:—H01n (H03f).

COMPLETE SPECIFICATION

Methods of Sealing and Protecting Electrical Components

We, THE NATIONAL CASH REGISTER COMPANY of Dayton in the State of Ohio, and Baltimore in the State of Maryland, United States of America, a Company organized under the laws of the State of Maryland, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

The present invention relates to methods of sealing and protecting electrical components, and more particularly to methods which provide protection for the components against adverse environmental conditions, such as shock, vibration, heat and humidity.

It is frequently necessary to provide such protection to electronic components when used in a variety of applications. A relatively simple and inexpensive method for accomplishing this has been to encapsulate the components to be protected within a plastic material which, in the uncured state, is fluid and which, in the cured state, is rigid and self-supporting. It has been found, however, that this method of potting, in many instances, does not provide the necessary protection against shock and vibration and thus, it has become necessary firstly to encapsulate the components in at least a thin coating of an elastic material prior to encapsulation within the plastic material.

It is, therefore, the object of this invention to provide methods of sealing and protecting electrical components which are relatively simple and inexpensive to carry into effect, and which overcome the disadvantages of the prior methods.

Accordingly the present invention comprises a method of sealing and protecting electrical circuit components, consisting of providing a pre-formed moulded encasing member of a hard self-supporting insulating material having a support member either integral with or fitted within said encasing member, said support member having at least one opening formed therein to connect upper and lower cavities formed by the support member in the encasing member, positioning the components within the opening or openings, at least partially filling the cavities with an elastomeric material entirely to encompass and cover the components, and curing the elastomeric material.

The above, and other subsidiary features of the present invention as applied, by way of example, to two manners of carrying it into effect, will now be described and are illustrated in the accompanying drawings:

Fig. 1 is a perspective external view of a first embodiment of the invention;

Fig. 1a is a detail view of a portion of the structure shown in Fig. 1 from the under surface thereof wherein certain underside portions are broken away to expose the interior thereof;

Fig. 2 is a cross sectional view of the structure shown in Fig. 1 taken along a portion of the line 2—2 and looking in the direction of the arrows;

Fig. 3 is a perspective view of a mould including a negative replica of a carrier for supporting magnetic cores in the structure shown in Fig. 1;

Fig. 4 is a plan view of the underside of the carrier utilized in the structure for supporting the cores of an array;

Fig. 5 is a vertical section of the carrier shown in Fig. 4 and taken on the line 5—5.

Fig. 6 is a diagrammatic view, partly in vertical section, of apparatus utilized in a method of forming the mould shown in Fig. 3;

Fig. 7 is a detail view of the structures shown in Fig. 1 showing typical toroidal magnetic cores and a typical winding having a plurality of turns threaded through the apertures of the cores;

Fig. 8 is an exploded view of the structure of the embodiment shown in Fig. 1;

[*Price* 4*s*. 6*d*.]

Price 25p

Fig. 9 is an external perspective view of a second embodiment of the invention;

Fig. 10 illustrates a 3×3 toroidal magnetic core array which may be encapsulated within the structure of Fig. 9;

Fig. 11 illustrates a printed circuit card having components mounted thereon which may be alternatively encapsulated within the structure of Fig. 9;

Fig. 12 is a cross section view of the structure shown in Fig. 9 taken along line 4—4 and looking in the direction of the arrows when the structure as illustrated in Fig. 10 is encapsulated;

Fig. 13 is a cross section view of a structure similar to that shown in Fig. 9 in which the printed circuit card of Fig. 11 is encapsulated;

Fig. 14 is a top plan view of a partial shell element;

Fig. 15 is a cross section view of Fig. 14 taken along line 7—7 and looking in the direction of the arrows;

Fig. 16 is a diagrammatic view, partly in vertical section, of the apparatus utilized in a single method of forming the partial shell element shown in Fig. 14.

First Embodiment

Referring to Figs. 1 and 1*a*, a rectangular magnetic core memory structure comprising an array of annular or toroidal magnetic cores 10 is supported in spaced relationship in a core plane by a core carrier plate 12 comprising a central plate portion 11 having a plurality of spaced circular openings 14 to provide close fitting seats for the cores, and a peripheral flange 30 surrounding the plate portion 11. As illustrated in Fig. 1*a*, the annular magntic cores 10, when seated in the openings 14, are positioned for maximum access to the core aperture 10^1 for the passage of winding conductors 16 which approach from a direction which is normal to the core plane and the plane of the carrier plate. The winding conductors 16 are readily passed through the same core aperture a plurality of times, by also passing the conductor through an adjacent core or an adjacent opening 14 in the carrier plate 12, to thereby provide core windings 17 having a plurality of turns. The windings illustrated in Fig. 7, for example, are shown having three turns in each winding.

The array of cores 10 and the winding conductors 16 are resiliently secured in a matrix 18 formed of cured soft elastic material, e.g. silicone materials including silicone rubber or polysiloxane or other elastomeric materials.

Referring now to Fig. 8, cover plates 20 and 22 are shown in alignment prior to being secured to respective sides of the core carrier plate 12 by suitable means. Bolts 24 passing through conjugate holes in the respective corners of the carrier and cover plates, are retained in position by respective nuts 26. A series of memory structures can be disposed one above the other and the structure can be mounted in position by passing elongated supporting members through the corner holes in a manner similar to bolts 24.

In Figs. 1 and 2, terminals 28 are shown disposed in the peripheral flange 30 of the core carrier plate 12 and about the core array to facilitate connection of the core windings 17 to external apparatus. The terminals 28 are shown as electrically conductive metal dowels having an intermediate shoulder which seats against the upper surface of the peripheral flange. As shown in Fig. 2, the lower portions of the terminals are passed through the flange 30 to provide for internal connections to the winding conductors 16. The lower portions of the terminals are embedded in the elastomeric material of the matrix 18 along with the cores 10 and the winding conductors 16.

The core carrier plate 12, as shown in Figs. 4 and 5, comprises a rectangular plate formed from rigid, and preferably, insulating material which can be cast or otherwise readily formed, e.g., organic materials; however, the plate could be formed of electrically conductive material which has been coated by an insulator, e.g. aluminium plate which has been hard-anodized. The lower and upper surfaces of the carrier plate 12 with peripheral flange 30 provide recesses 32 and 40 to receive the matrix material 18. The larger recess 32 extends beyond the ends of terminals 28. Thus, as shown in Fig. 2, the ends of the terminals are located within the larger recess 32 whereby the terminal connections are embedded in the elastomeric material forming the matrix 18. The openings 14, providing the close fitting seat for the magnetic cores, open into the larger recess 32 whereby the cores may be placed into the openings 14 from the lower side of the carrier plate 12 as shown in Fig. 4. A hole 34 is provided centrally of each opening 14 for the passage of the winding conductors through the core apertures and through the carrier plate.

The peripheral area adjacent the core array is perforated to accomodate the shanks of the terminals 28, the lower portions of which pass through the carrier plate 12. The outer periphery of the flange 30 is provided with holes 38 for the passage of the bolts 24 or other support members. As shown in Fig. 2 the recess 40 accommodates the winding conductors within the core plate whereby the matrix 18 filling the recess will embed the conductors in the soft elastic material to resiliently secure them from relative movement due to vibration, shock or the like.

The carrier plate 12 may be produced by first forming a master carrier plate 50, shown in Fig. 6. The master carrier plate is similar in shape to the cast carrier plate 12 shown in

Figs. 4 and 5. Preferably, the master carrier plate is formed from a rigid material, such as an easily machined metal, and includes an array of counterbores which are disposed in a pattern arrangement identical to the openings 14, and other openings in the carrier plate 12.

The process for producing carrier plates 12 from the master carrier plate 50, is illustrated in Fig. 6, which shows a cross section of the master plate 50 which, with the exception of recess 40, has the identical shape as the cross section of the carrier plate 12, shown in Fig. 4. Openings 51, for example, in master plate 50 correspond to holes 62 in plate 12 and openings 51^1 in master plate 50 correspond to openings 14 and apertures 34 in plate 12. This process includes the steps of placing the master, facing upwardly, in an open receptacle or box form 52 and applying or pouring an uncured elastic material 54, such as silicone material, over the exposed surfaces 56. After the elastic material 54 envelops or covers the entire upper surfaces of the master carrier plate 50, the material is allowed to cure or set. Once the material has set, a cured mould such as the mould 58, shown in Fig. 3, is separated from the master carrier plate. This mould 58 has a negative replica of the master plate formed in its cavity 60. The next step in making the carrier plate 12 is to apply a material such as polymerized acrylic resin, into cavity 60 over the exposed surfaces 59. After this resin material envelops or covers the entire surfaces of the mould 58, the material is allowed to cure or set, after which the thus formed carrier plate 12 is removed. This mould 58 can be used to form many carrier plates 12 by filling the cavity 60 with uncured material and, after curing, removing the rigid casting so formed from the cavity 60. After removal, the recess 40 is then machined on the cast carrier plate.

Referring to Figs. 4 and 5 once more, holes 62 and 63 are shown to have been formed in the cast carrier plate 12 to connect the recesses 32 and 40. Peripheral holes 62 and intermediate holes 63 provide convenient access for the winding conductors 16 to either side of the carrier plate whereby the cores can be wound in the proper direction to provide a desired polarity of the winding on the individual cores.

The magnetic memory core assembly is constructed to provide maximum access to the core apertures during winding of the cores 10 which are positioned in the apertures 34 in the carrier plate 12.

In the assembly of the magnetic memory core structure, the annular magnetic cores 10, shown in Fig. 1*a*, are seated in the openings 14 and the conductors 16 are threaded through the core apertures 10^1, the openings 14 and holes 62 and 63 in the carrier plate in a predetermined sequence to provide core windings which are interconnected in a desired manner for the magnetic core array. The ends of the conductors are connected to the terminals 28 which extend through the carrier plate 12 to provide external input and output connections. The matrix 18 is formed subsequently by embedding the cores and windings in a soft elastic material and closing off the recesses 32 and 40, e.g., by the cover plates 20 and 22, as shown in Fig. 8. In the preferred process, special plates are used to close off the recesses 32 and 40 during the forming of the matrix which is accomplished by forcing an uncured soft elastic material into the recess 32 through an aperture in the special cover plate similar to plate 22. If the uncured matrix material is injected with adequate pressure, it will surround the cores and windings and pass through the core aperture and holes in the carrier plate 12 and also fill the recess 40. Upon the curing of this material, a soft elastic matrix is formed for resiliently supporting the cores and coil winding conductors. The special plates used to close off the recesses 32 and 40 during the forming of the matrix are removed after the material sets. Subsequently, cover plates 20 and 22 are bonded to the opposing portions of the carrier plate and matrix by a suitable adhesive. The bolts 24, which are shown passing through the corresponding holes in the cover plates and carrier plate, could be used as permanent retaining means if rods or other elongated support means are not utilized to mount the memory structure along with other memory structures in a suitable enclosure.

In the arrangement of the memory structure, as illustrated in Figs. 1a, 2 and 7, the material forming the matrix 18 fills all the recesses or cavities between the cover plates 20 and 22 in addition to merely surrounding the cores 10 and conductors 16

In an alternative arrangement, the matrix is formed from two or more materials. The soft elastic material is applied to the carrier cores and wires and surrounds substantially only the cores and wires and an organic foam is applied over the cured soft elastic material, filling the recesses 32 and 40 in the carrier. After the organic foam, e.g. polyurethane, has hardened, it acts to inhibit relative movement of the cores and wires and central area of the carrier plate relative to the peripheral flange in response to vibration and shock. For the more severe environmental conditions, the construction of the alternative arrangement provides additional protection to the memory elements and windings, although the more economical construction of the preferred arrangement has been found satisfactory.

SECOND EMBODIMENT

Although a variety of elements may be shock and mechanically protected by this embodiment of the invention, a magnetic core

array and a printed circuit board having components mounted thereon will be used as examples in describing its features.

In Figure 10, there is illustrated a 3×3 toroidal magnetic core array wherein a carrier card is indicated by reference numeral 70 and the cores are indicated by reference numeral 10.

Figure 11 illustrates a printed circuit carrier board 71, which may be similarly protected and which has eight resistors 72, two capacitors 73, and two transistors 74 mounted thereon.

Referring now to the drawings there is shown in Figure 9 a rectangular magnetic core memory structure comprising an array of annular or toroidal magnetic cores, as shown in Figure 10, encapsulated within a rigid self-supporting casing of plastic material.

A casing 75 may be cast or moulded of a rigid self-supporting plastic material. This material may be selected from the general class of plastics the properties of which are such that in the uncured state they may be readily poured or moulded and in the cured state they are rigid and self-supporting. Two examples of plastic materials of this type are the general epoxy and acrylic classifications. The details of the casing 75 are indicated by the top plan view of Figure 14 and the cross section view thereof of Figure 15, as viewed in the direction of the arrows along line 7—7. It may be noted that this casing includes a recessed portion 76, which is arranged to accomodate and locate therewithin the units to be protected.

One method of forming the casing 75 is illustrated in Figure 16, which shows in cross section a mould 77 having a frame 78, which may be of wood or metal, and a plug 79, which also may be of wood or metal. The contour of plug 79 is such as to produce and is identical in cross section with the recessed portion 76 of the partial shell element 75, as indicated. A plastic material 80, having the properties hereinbefore described, such as, for example, an epoxy or acrylic resin, is poured in the uncured state into the mould 77 until it envelops the contours of the plug 79 and completely fills the mould 77. At this time, the plastic material 80 is permitted to cure or set in the manner required by the specific material used. After the plastic material 80 has cured, it is removed from the mould 77 in the form of the rigid self-supporting casing 75. Mounting holes 81 may be cast within the casing 75 or may be drilled later, as desired. The casing 75 may also be compression or injection moulded, if desired.

The matrix forming material which will flow freely in the uncured state but which possesses soft elastic properties in the cured state is now introduced into recessed portion 76 to form the shock mounting matrix 18.

The units to be protected may be placed within recessed portion 76 at this time in such a manner that the uncured matrix forming material completely surrounds them, as indicated in Figures 12 and 13, wherein the matrix is indicated by reference numeral 18. By placing the card 70 of the magnetic core array illustrated in Figure 10 upon the shoulder 82 of casing 75, the magnetic cores 10, are accommodated and located within the recessed portions 76, as indicated. Similarly, if the card 71 of the printed circuit board illustrated in Figure 11 is placed upon the shoulder 82 of the casing 75, the resistors 72, the transistors 74, and the capacitors 73 are accommodated and located within the recessed portion 76 as indicated.

It is to be specifically understood that the order of the last two described steps of the process may be reversed. That is, the units to be protected may be first located within the recessed portion 76 and the uncured matrix forming material then introduced therein. For example, the card 70 of the magnetic core array may be located upon the shoulder 82 of the casing 75, as previously described, and the uncured matrix-forming material then introduced into the recessed portion 76 through opening 83. Similarly, through the provision of an opening in the card 71 of the printed circuit board, the uncured matrix-forming material may be introduced into the recessed portion 76 after the card 71 has been located upon the shoulder 82.

The matrix-forming material is then cured to its proper soft elastic consistency with the units to be protected in place whereby it becomes a soft elastic shock mounting material which surrounds and resiliently supports the selected units to be protected, as shown in Figures 12 and 13.

After the matrix-forming material has been cured, the remainder of the recessed portion of casing 75 is filled with uncured plastic material. With the elastic matrix and the units to be protected being completely covered, the final assembly may be cured, thereby completing a potted element in which the units to be protected are surrounded and resiliently supported by a soft elastic shock mounting matrix and encapsulated within a rigid self-supporting plastic material which provides mechanical protection.

WHAT WE CLAIM IS:—

1. A method of sealing and protecting electrical circuit components, consisting of providing a pre-formed moulded encasing member of a hard self-supporting insulating material having a support member either integral with or fitted within said encasing member, said support member having at least one opening formed therein to connect upper and lower cavities formed by the support member in the encasing member, positioning the components within the opening or openings, at

least partially filling the cavities with the elastomeric material entirely to encompass and cover the components, and curing the elastomeric material.

2. A method according to Claim 1, including the further step of passing electrical conductors through the components and the openings a plurality of times prior to filling the cavities with the elastomeric material.

3. A method according to Claim 2, including the additional step of filling the cavities with an organic foam to include therein the components and conductors surrounded with cured elastomeric material.

4. A method according to Claim 2 or Claim 3, including the further step of securing cover plates to the respective upper and lower surfaces of the encasing member to enclose the cavities.

5. A method of sealing and protecting electrical circuit components substantially as herein before described with reference to Figs. 1 to 8 and Figs. 9 to 16 of the accompanying drawings.

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Agent for the Applicants.
Application No. 30963/60.

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Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

FIG. 1

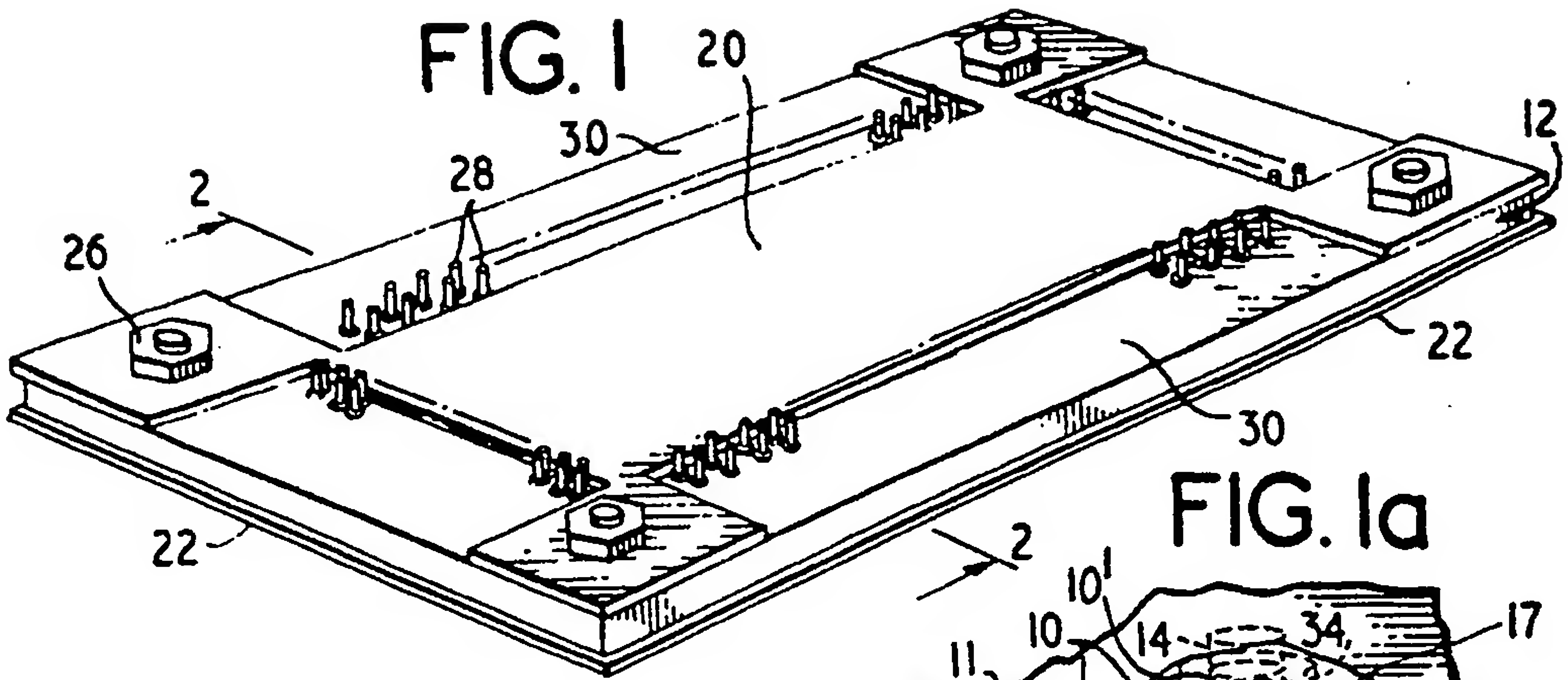


FIG. 1a

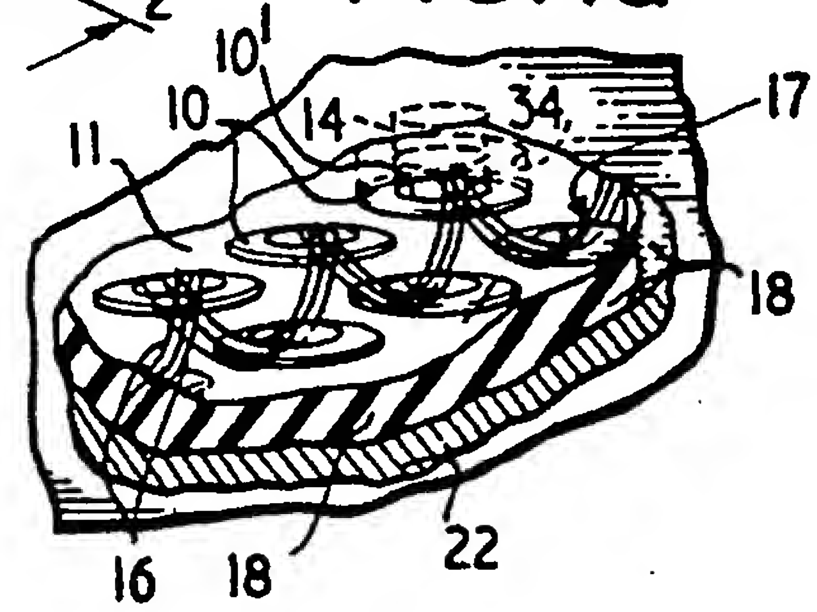


FIG. 2

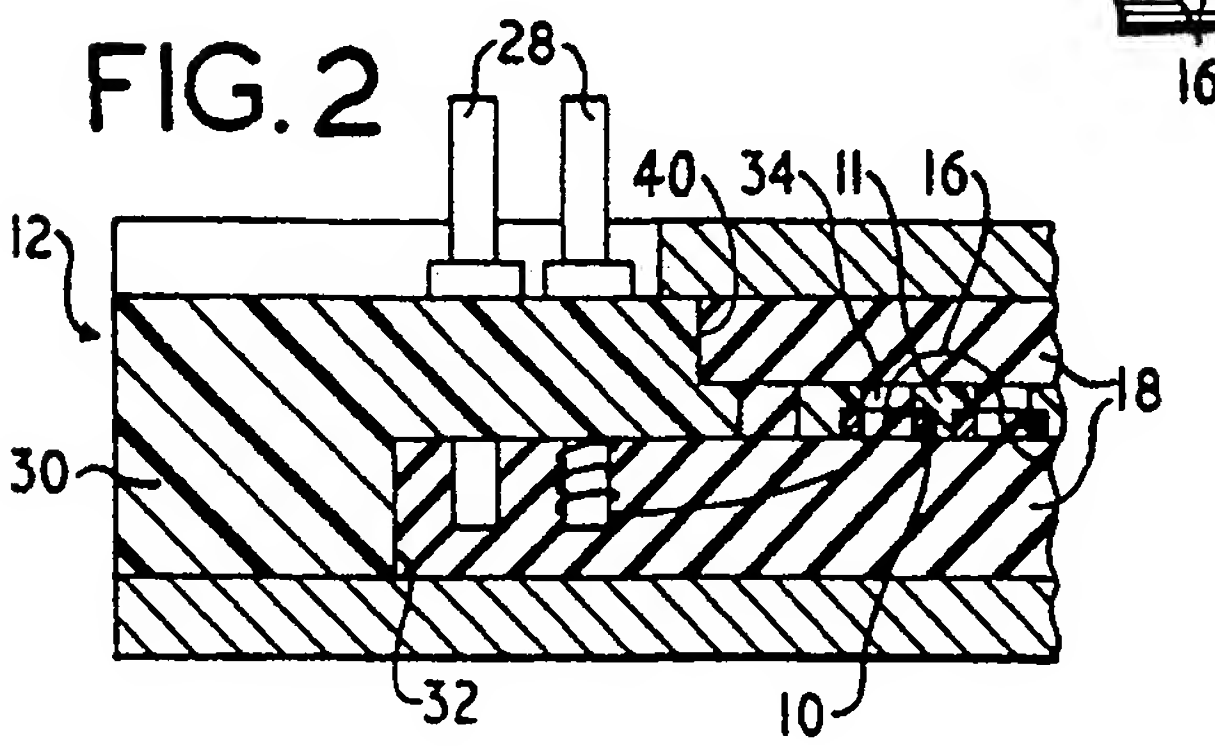
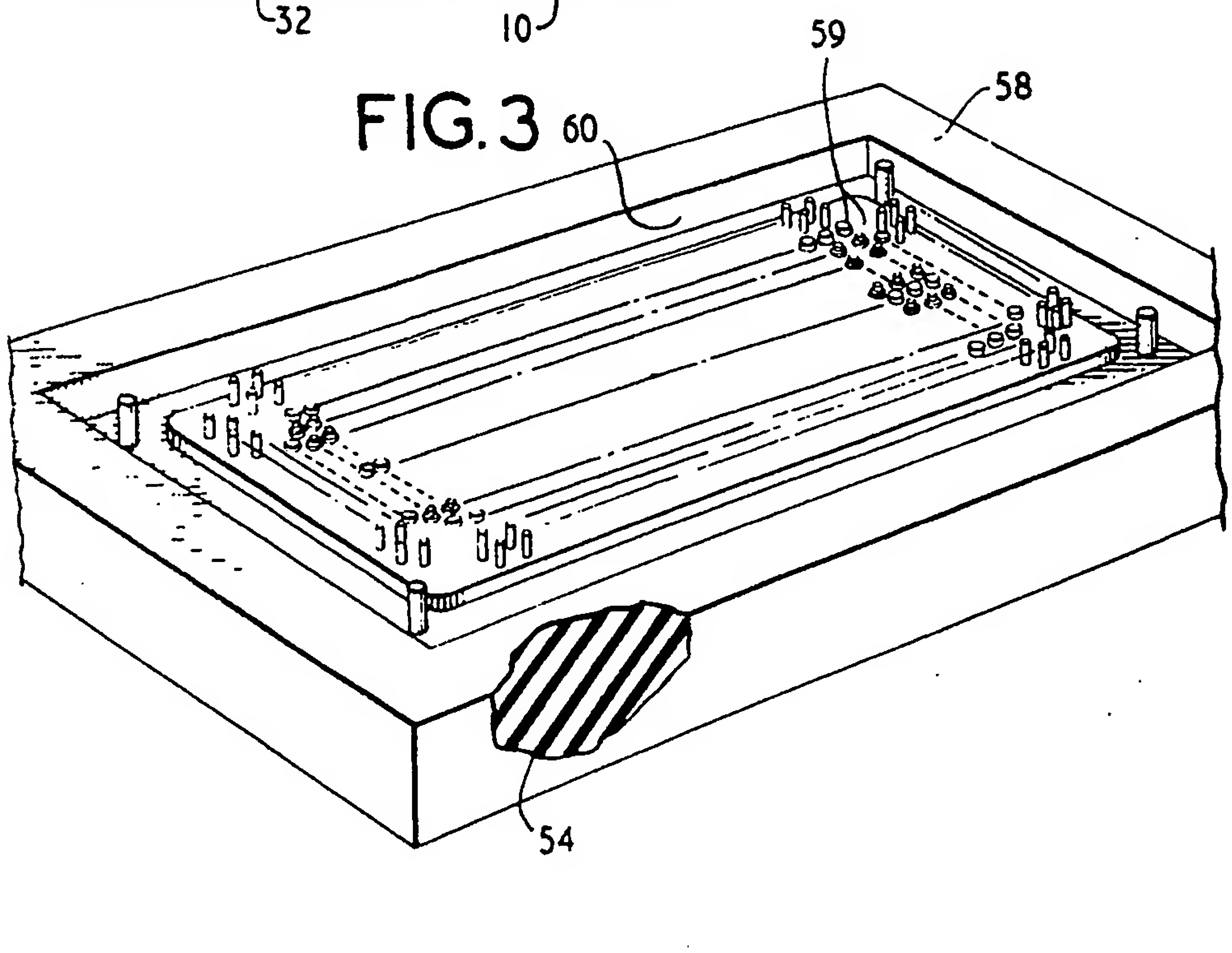


FIG. 3



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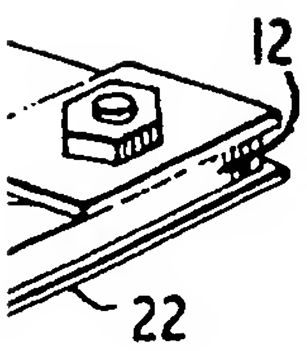

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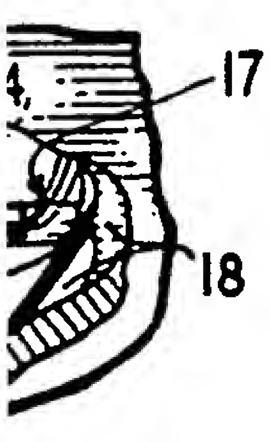


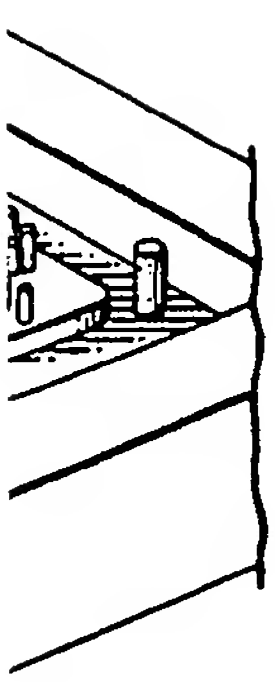


FIG. 4

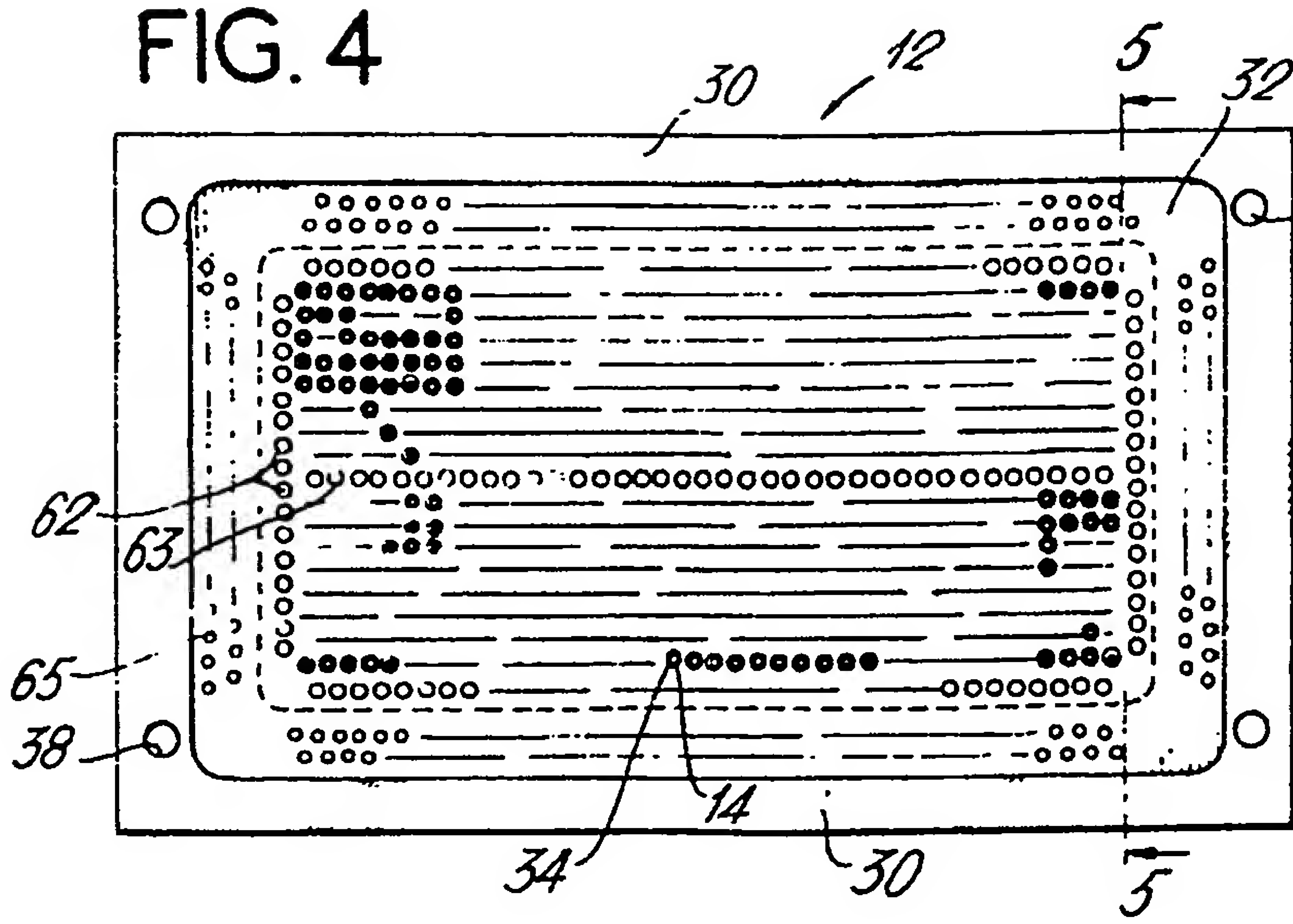


FIG. 5

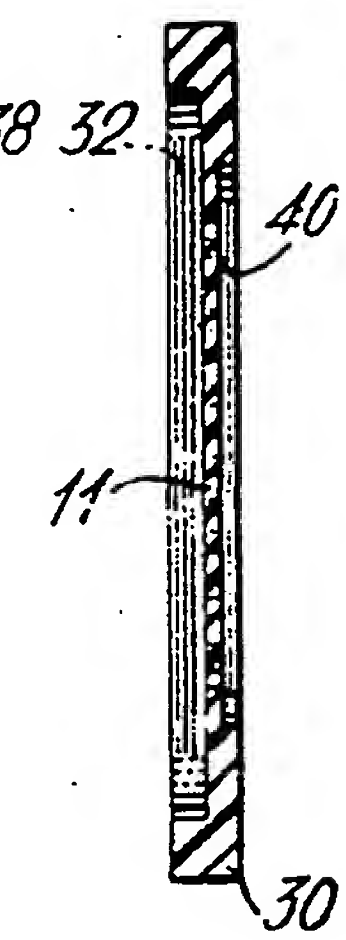


FIG. 6

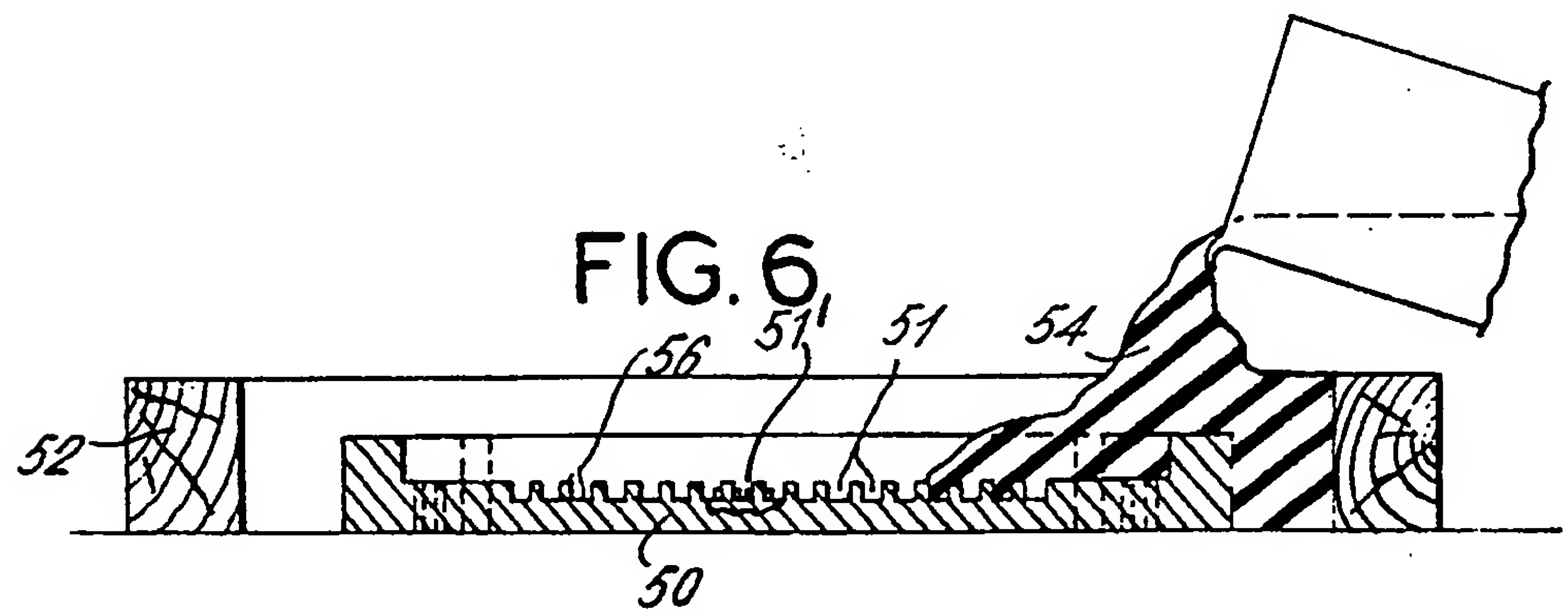


FIG. 7

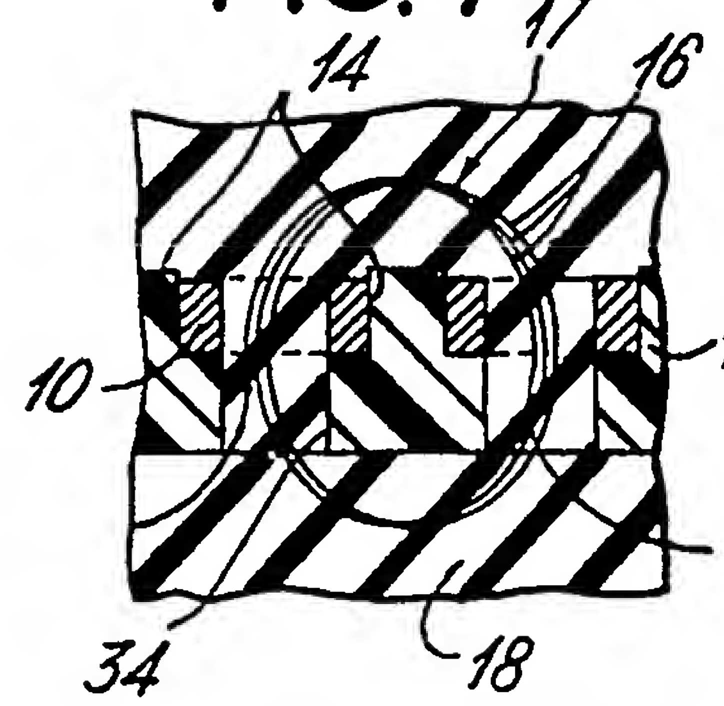
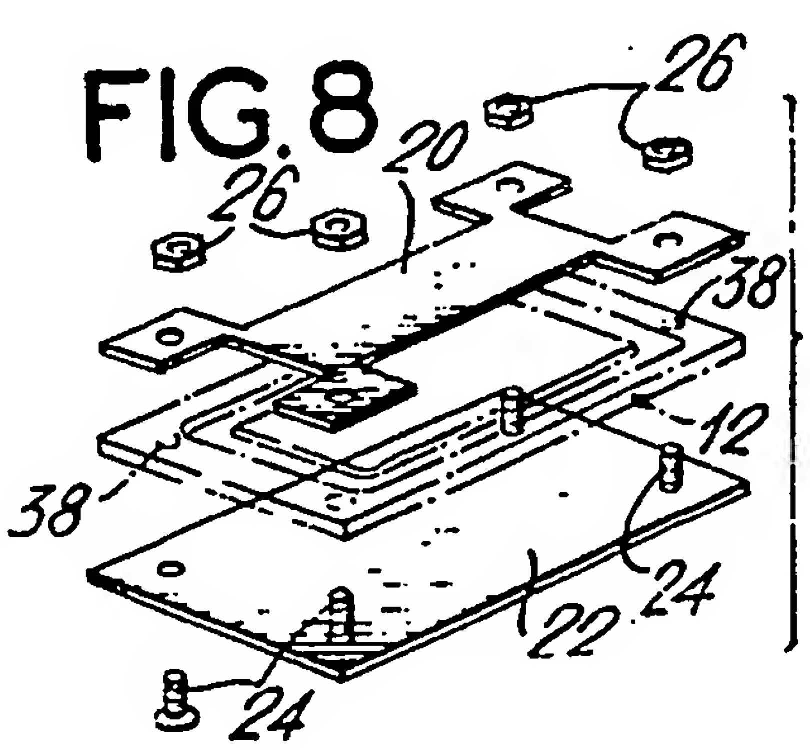


FIG. 8



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SHEETS 1 & 2

FIG. 1

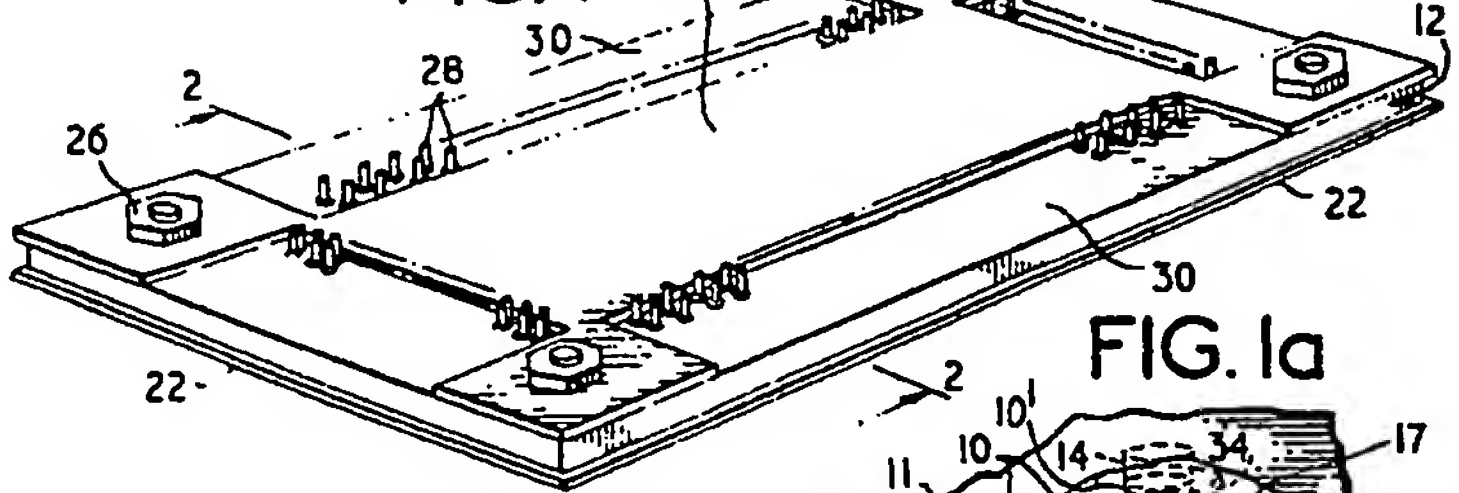


FIG. 1a

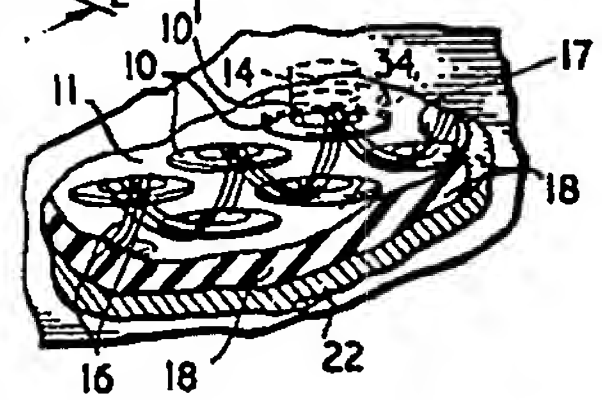


FIG. 2

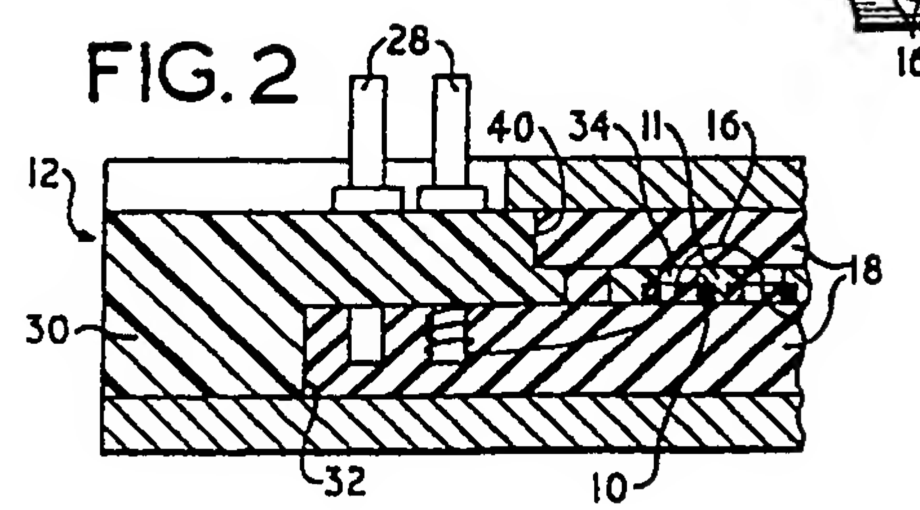


FIG. 3

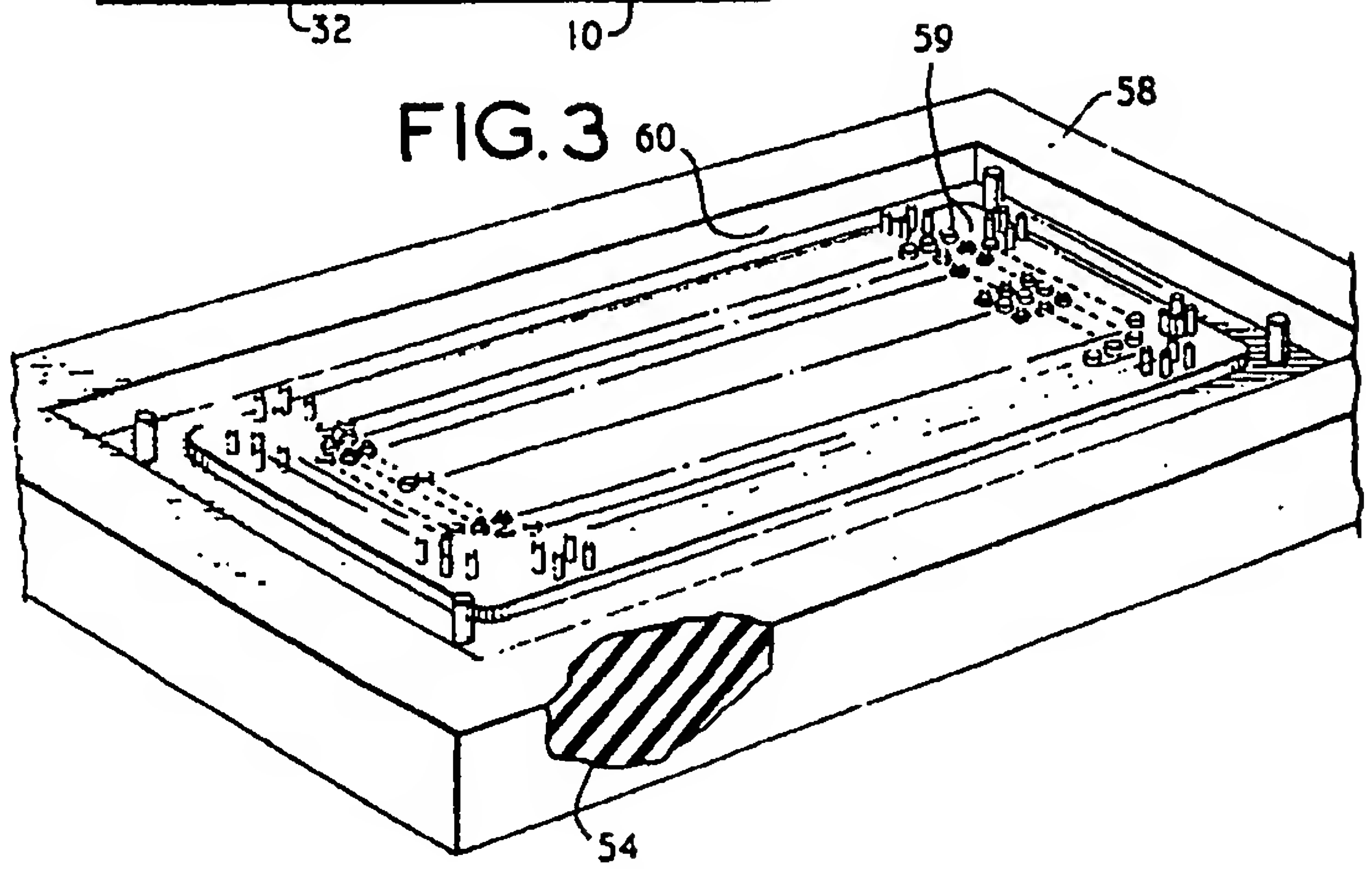


FIG. 4

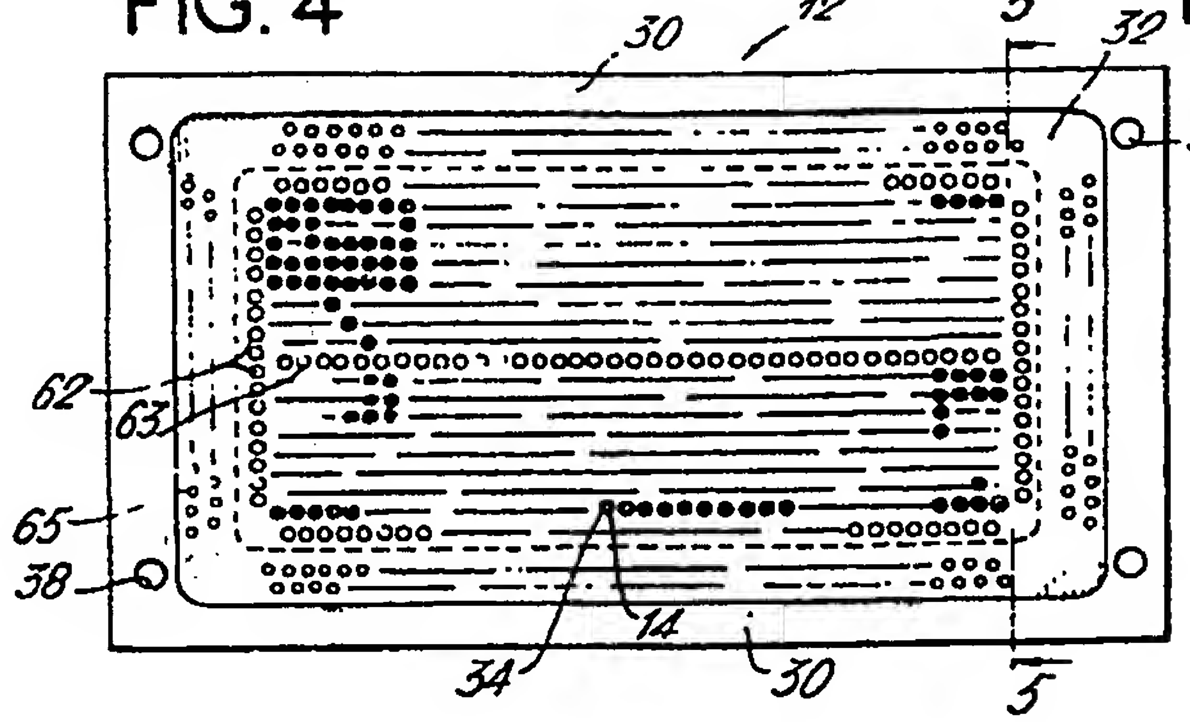


FIG. 5

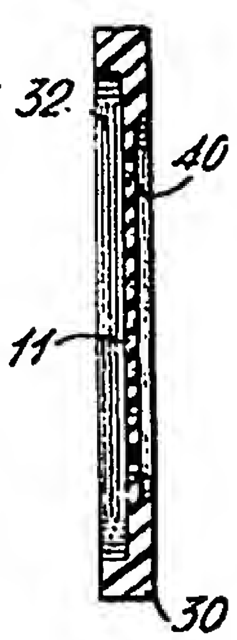


FIG. 6

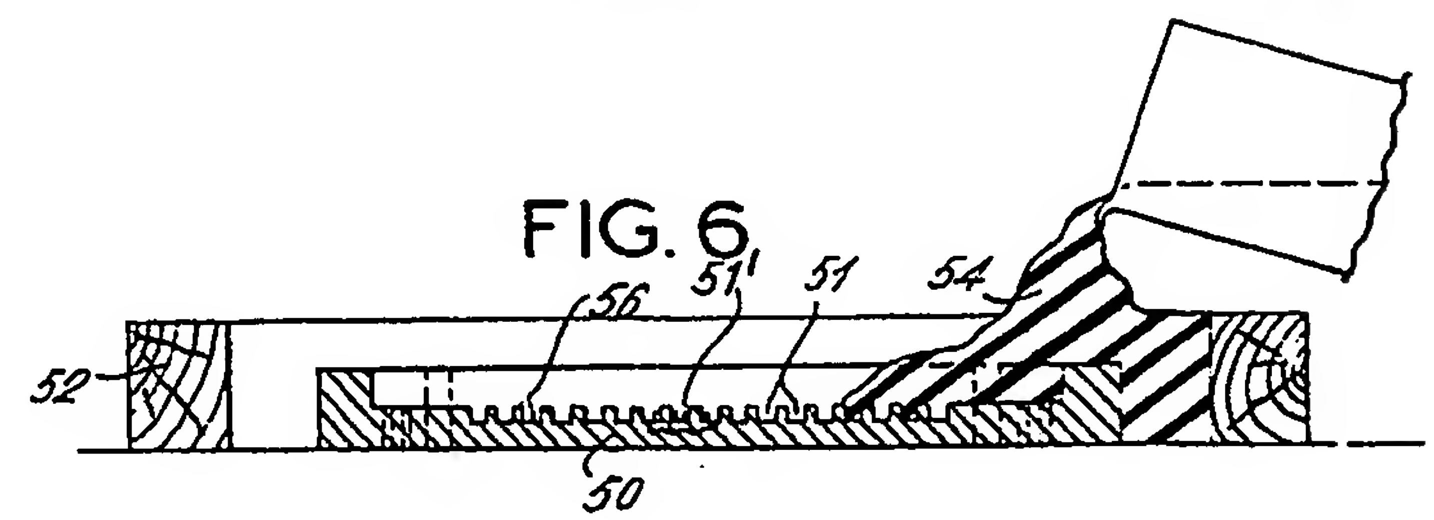


FIG. 7

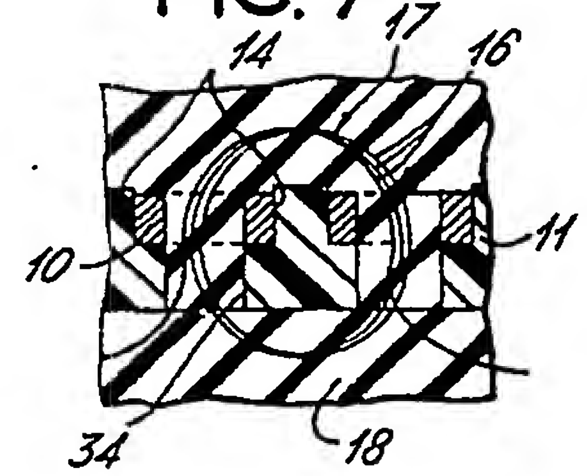


FIG. 8

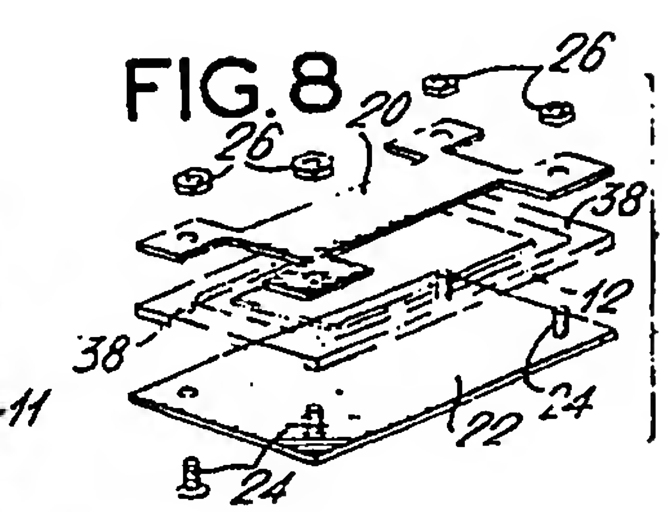


FIG. 9

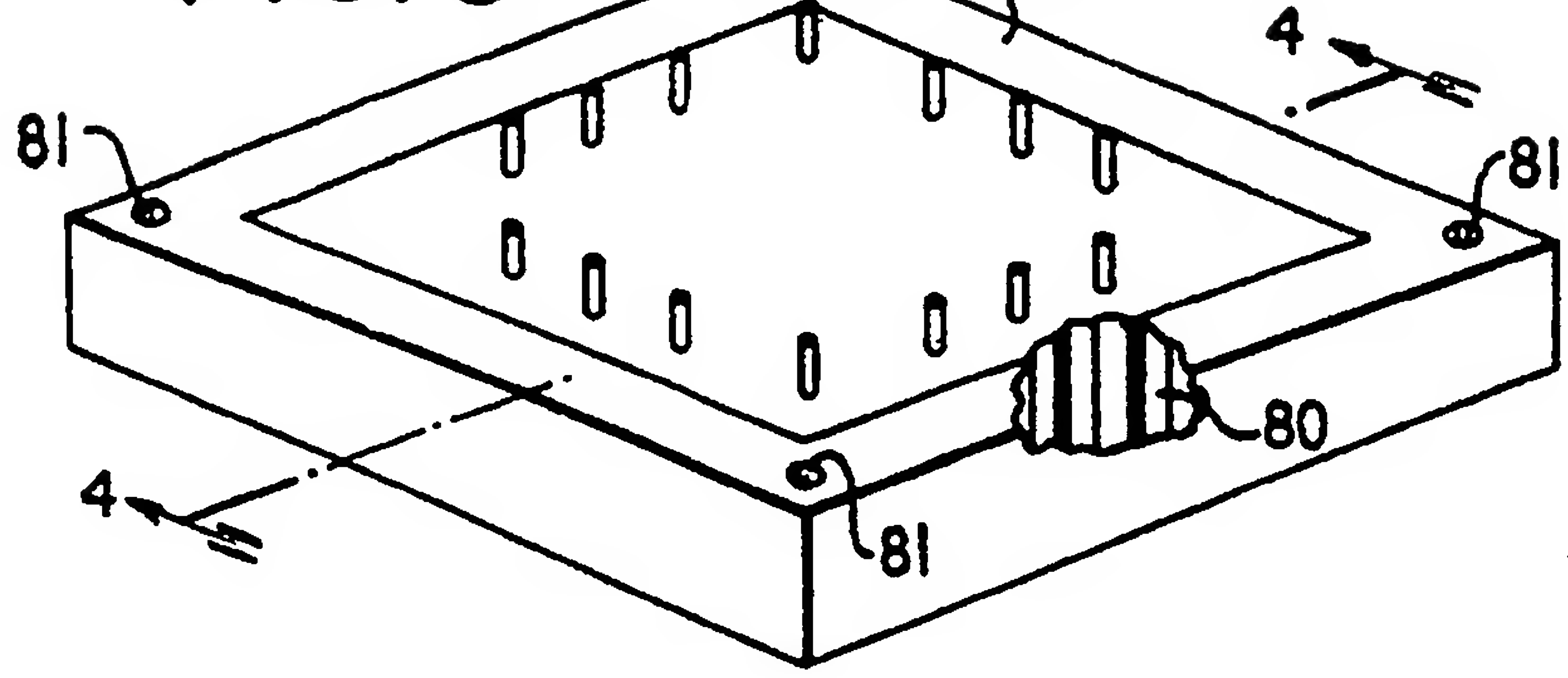


FIG. 10

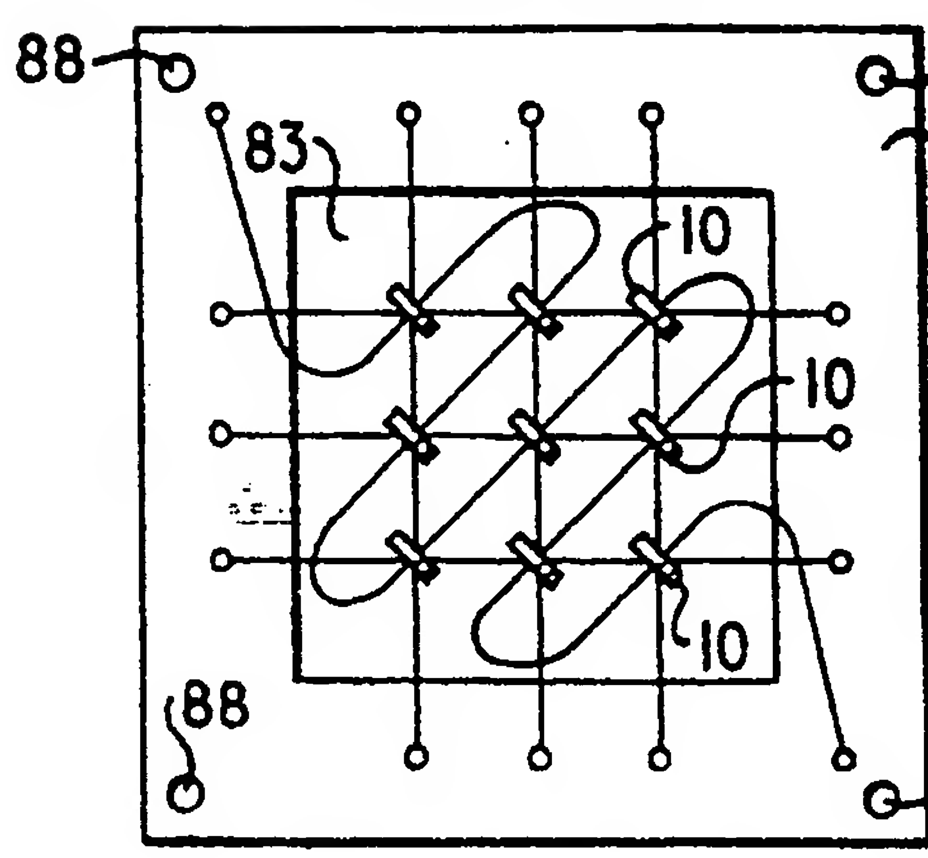


FIG. 11

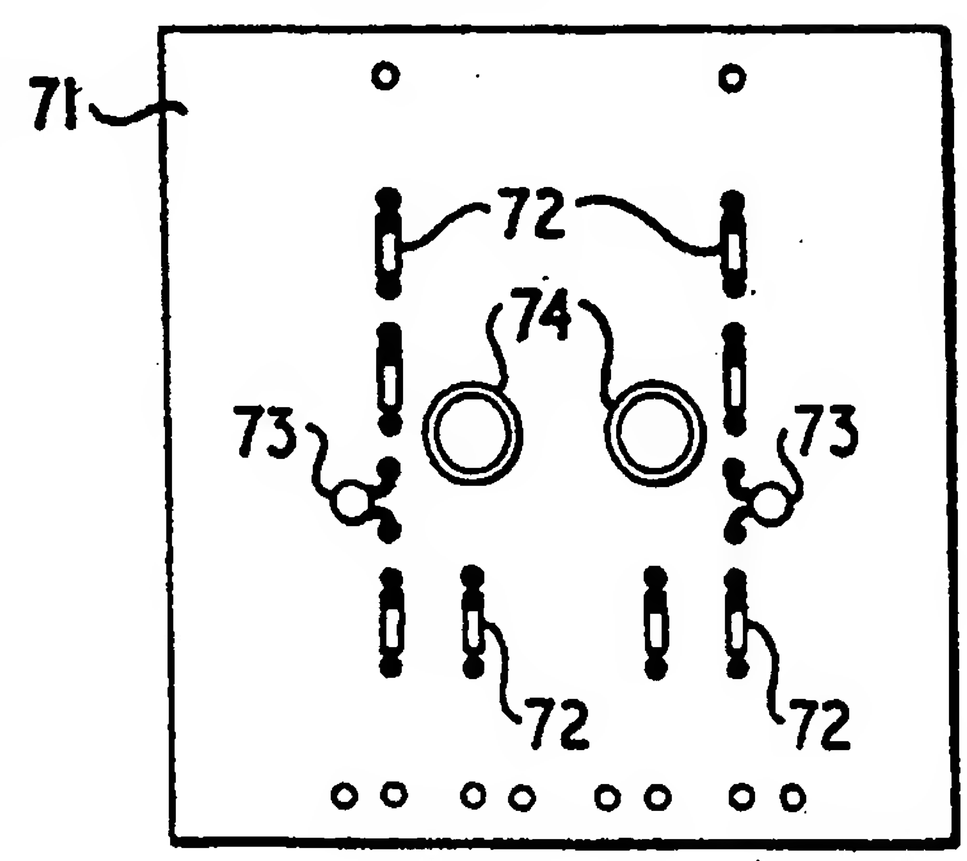


FIG. 12

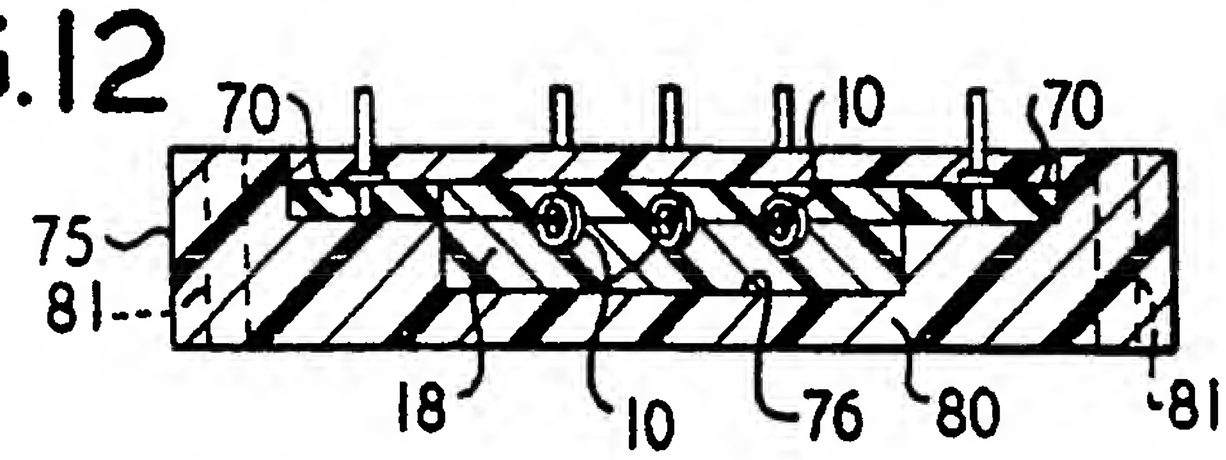
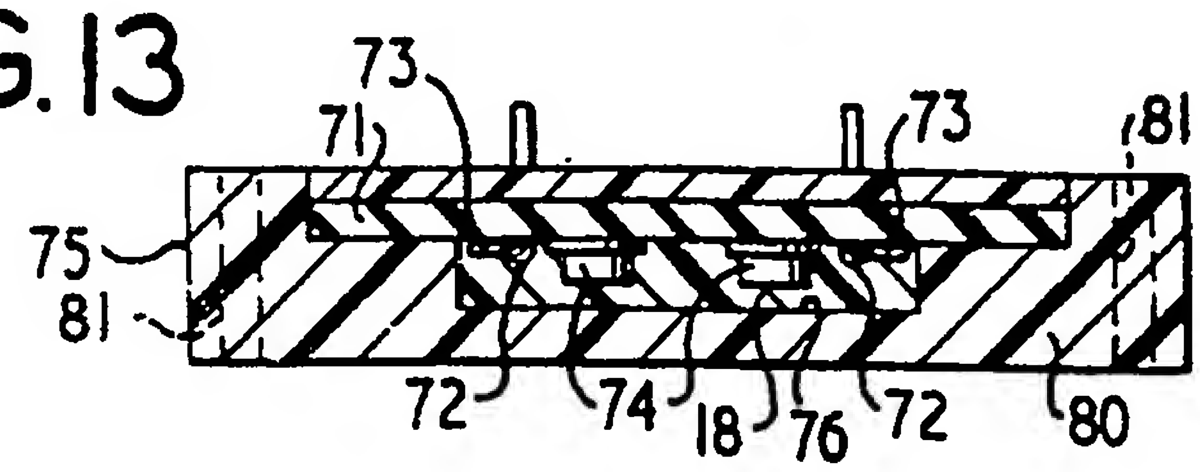


FIG. 13



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SHEETS 3 & 4

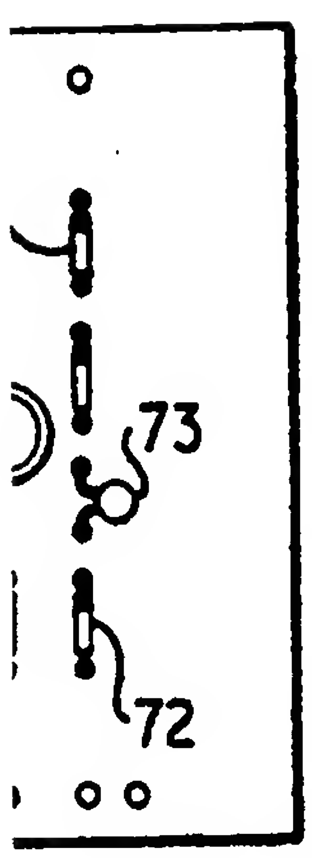

FIG.14

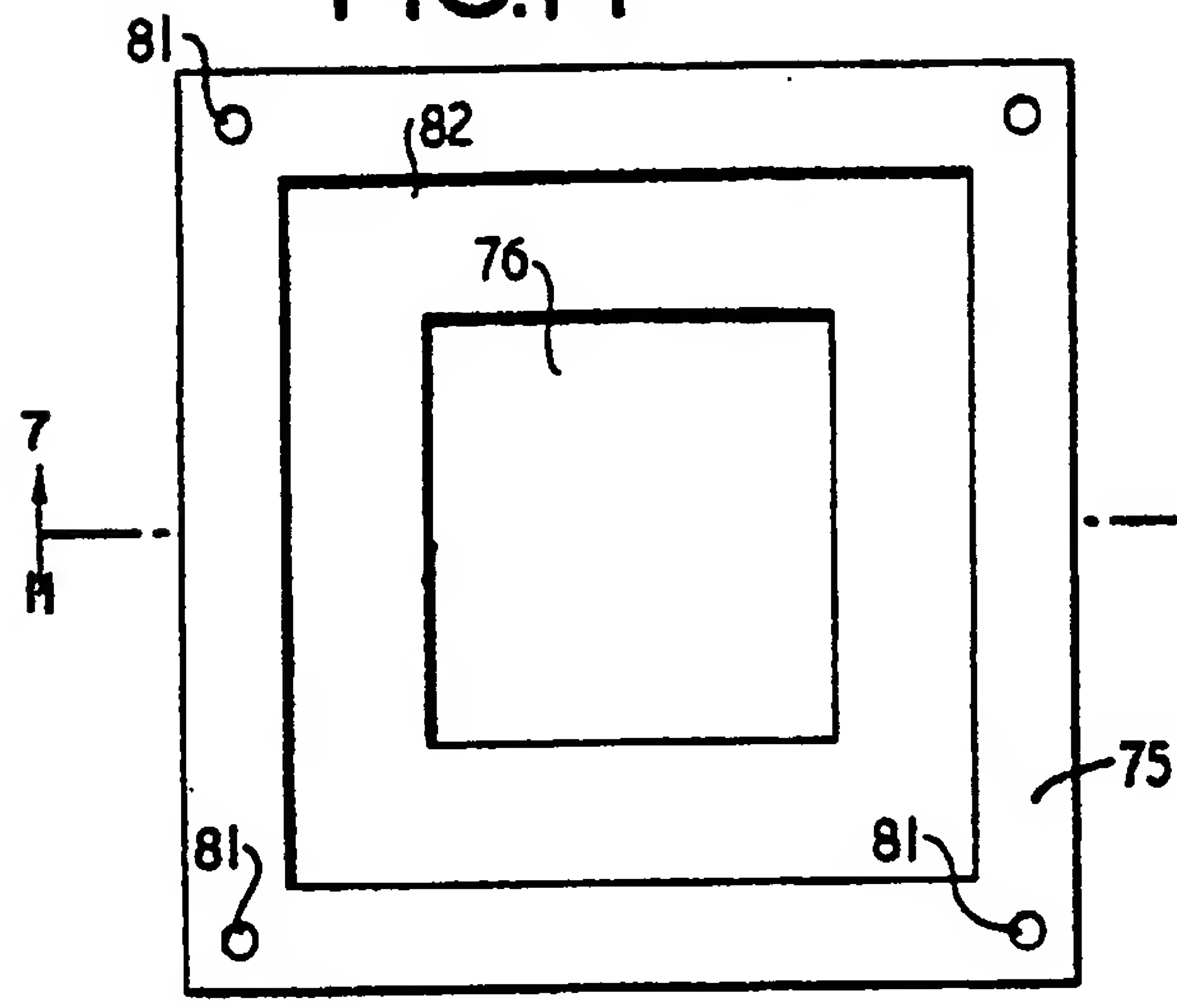

FIG.15

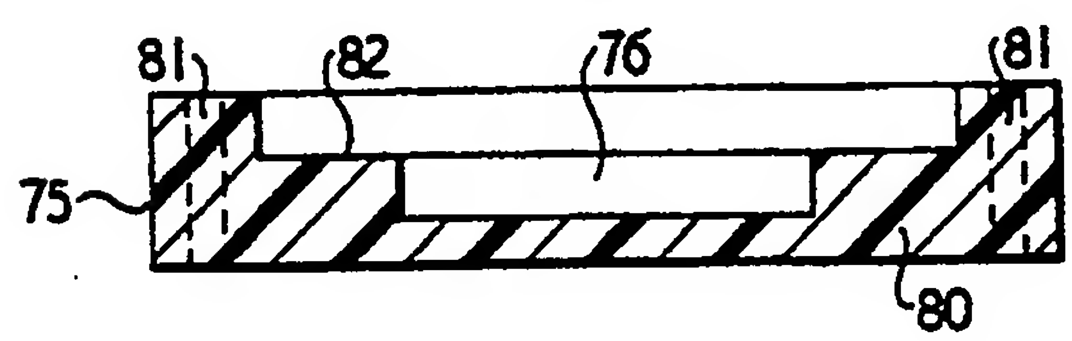

FIG.16

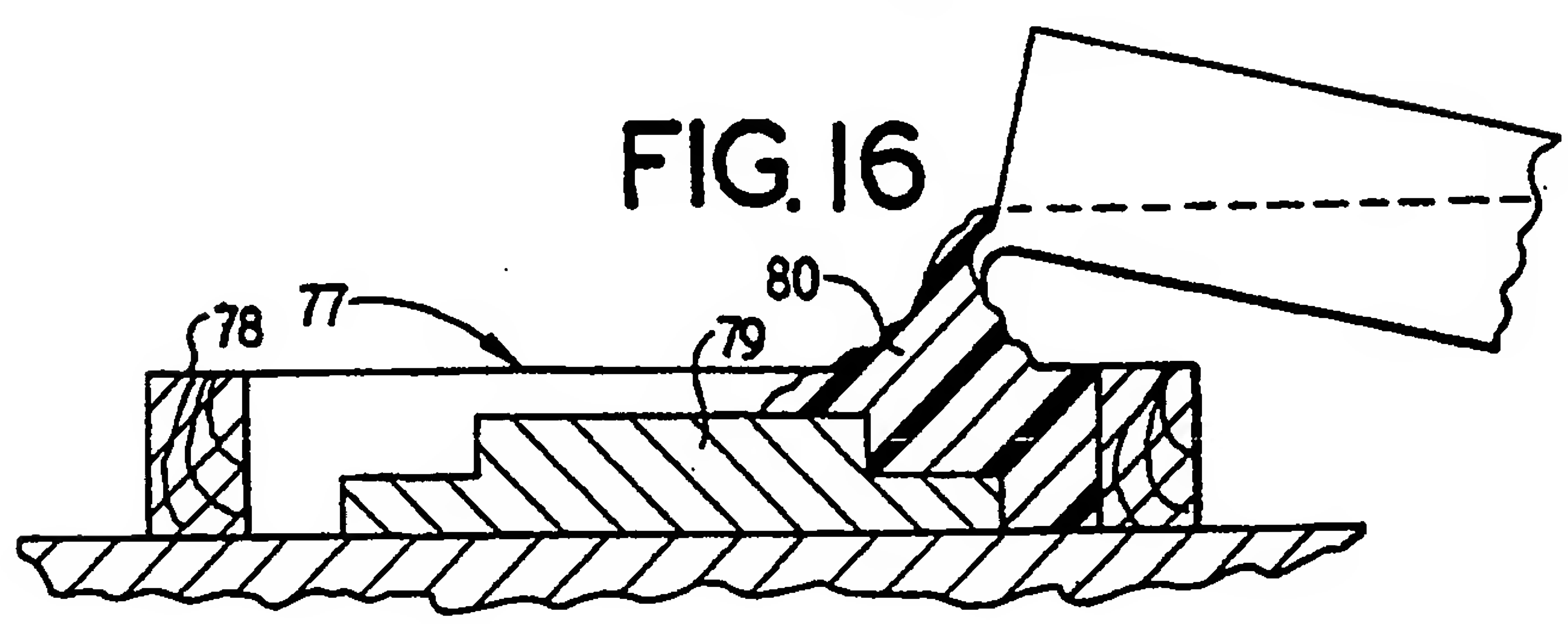

FIG. 9

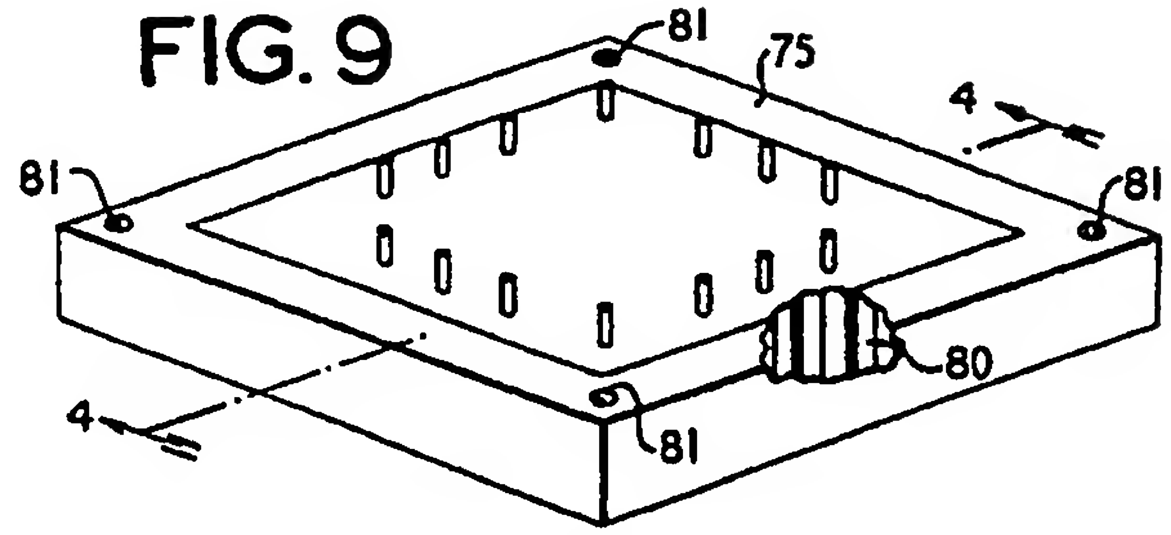

FIG. 10

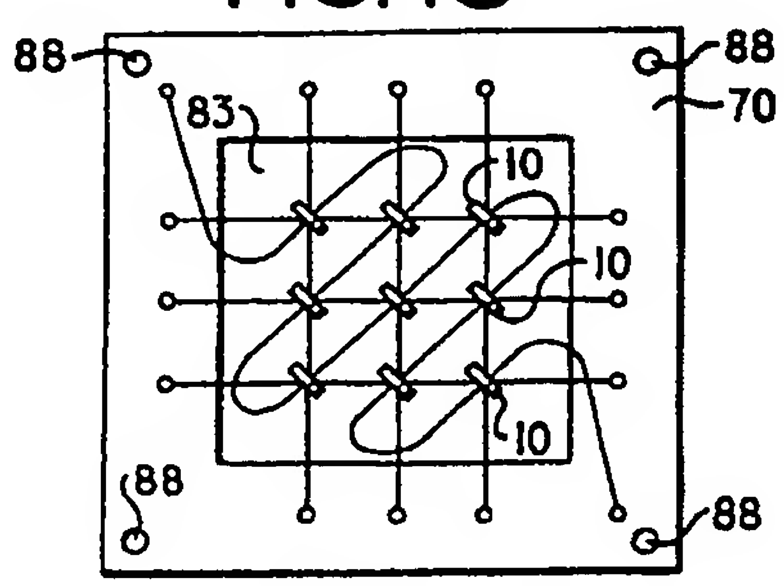

FIG. 11

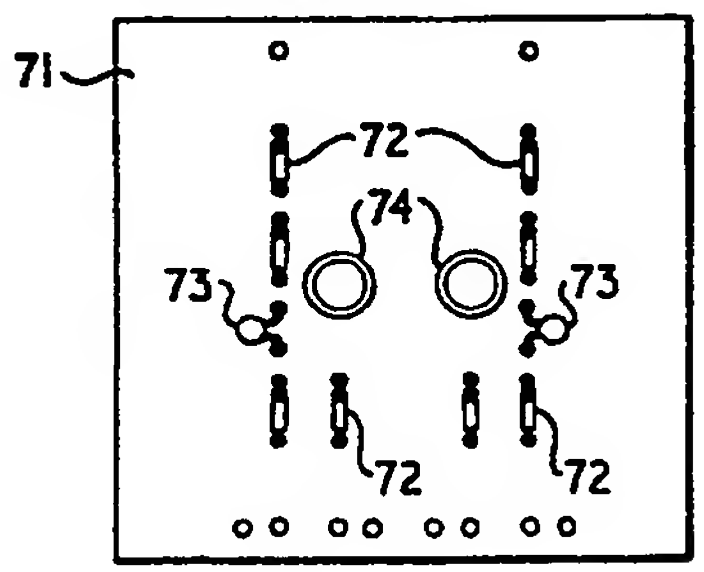

FIG. 12

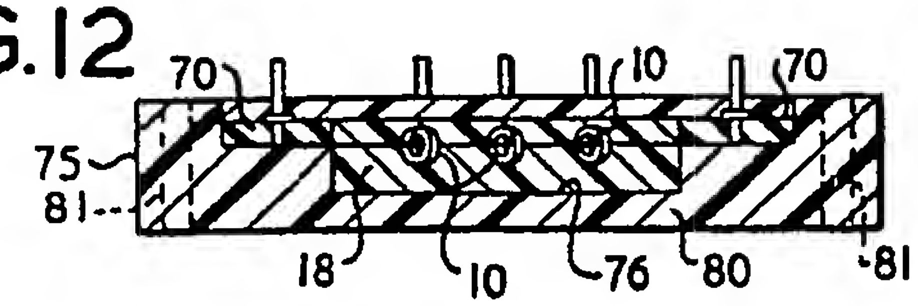

FIG. 13

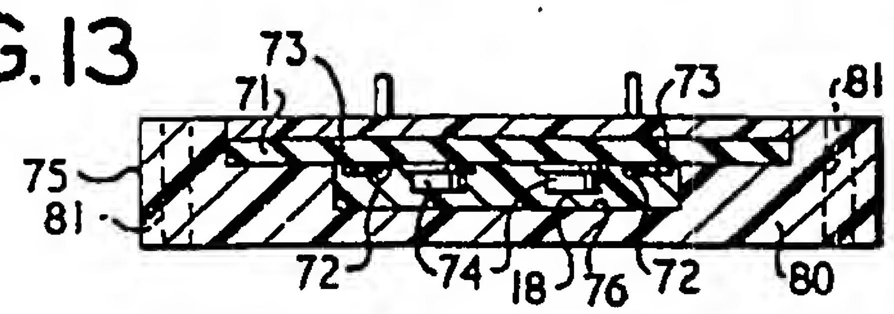

FIG. 14

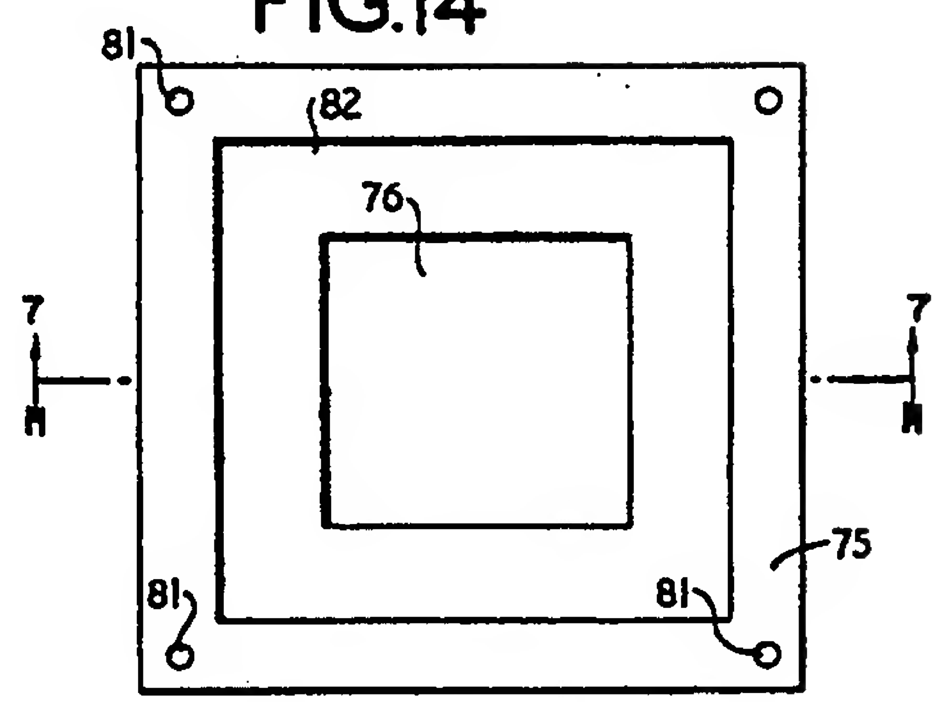

FIG. 15

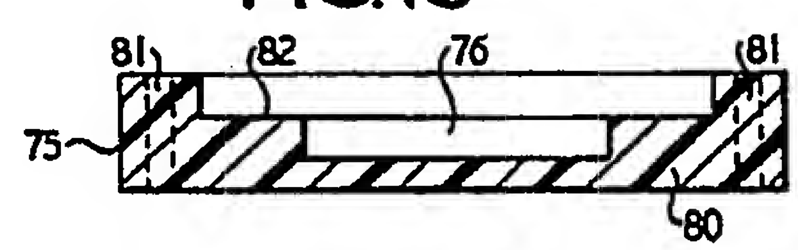

FIG. 16